National Aeronautics and Space Administration

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# The Rapid Response Radiation Survey (R3S) mission using the HISat Conformal Satellite Architecture

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This presentation was developed in partnership with NovaWurks Inc.*

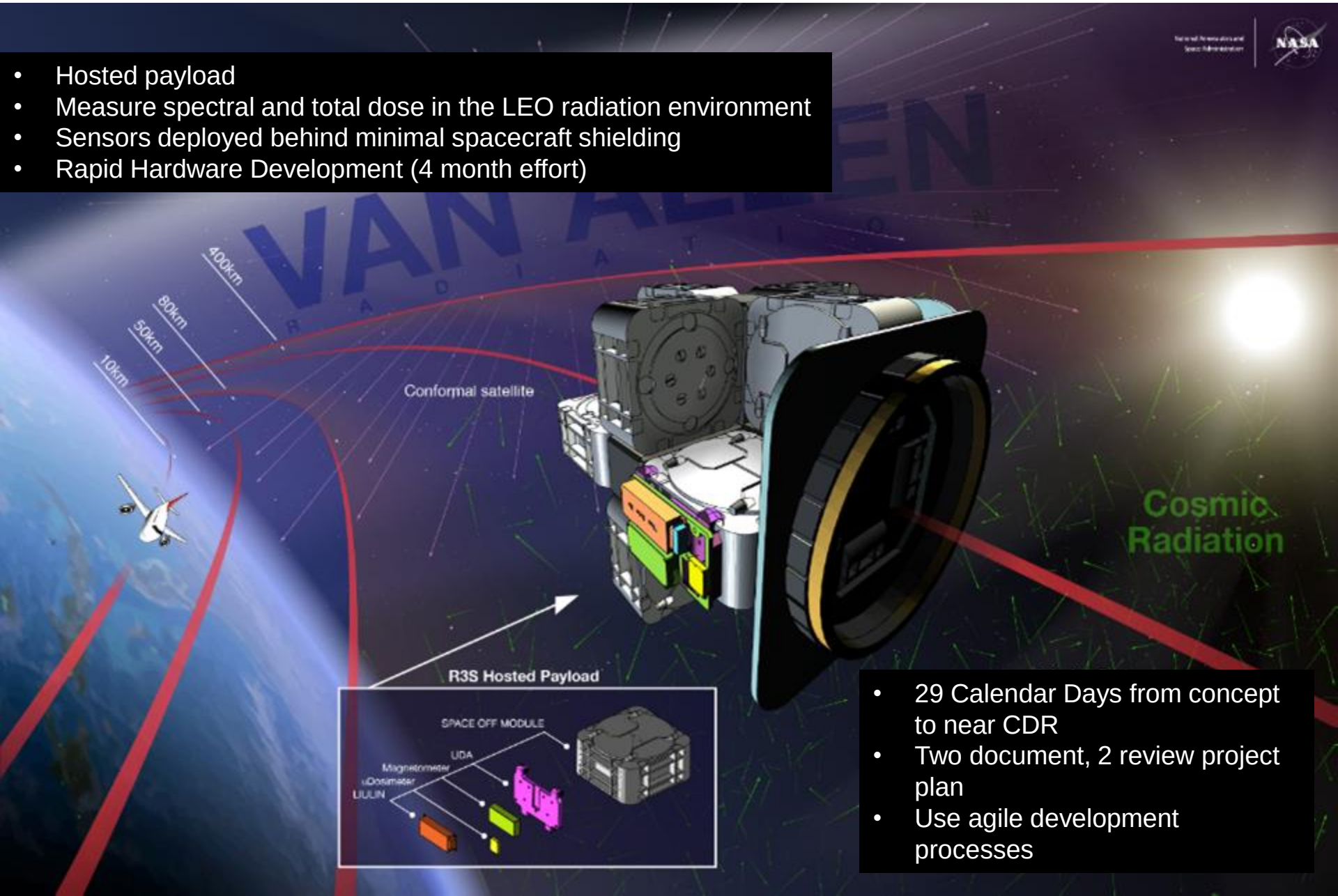
## Author's Note

- The views, opinions, and/or findings contained in this article/presentation are those of the author(s)/presenter(s) and should not be interpreted as representing the official views or policies of the Department of Defense or the U.S. Government."

*Space for Everyone

# Overview of Rapid Response Radiation Survey (R3S)

- Hosted payload
- Measure spectral and total dose in the LEO radiation environment
- Sensors deployed behind minimal spacecraft shielding
- Rapid Hardware Development (4 month effort)

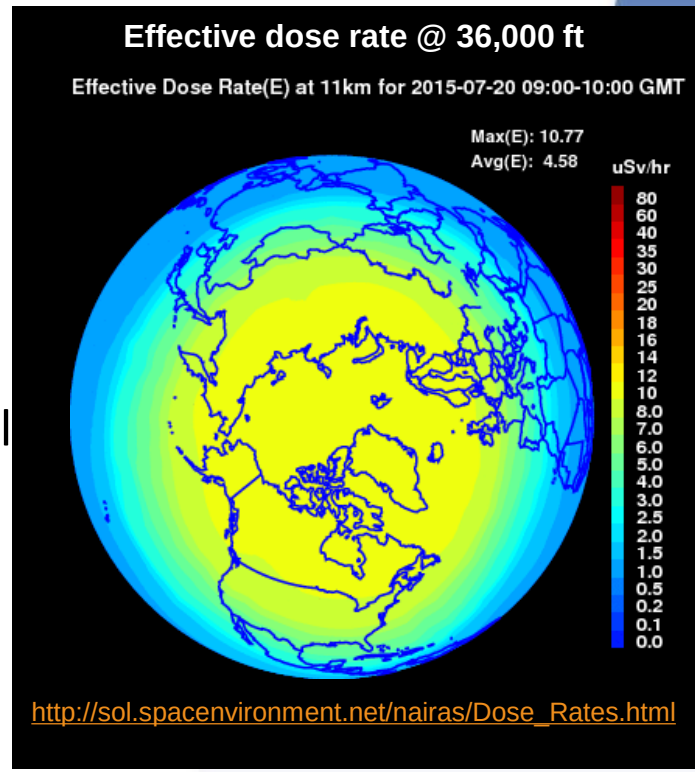



- 29 Calendar Days from concept to near CDR
- Two document, 2 review project plan
- Use agile development processes

# Motivation for R3S

## Nowcast of Atmospheric Ionizing Radiation for Aviation Safety

- Assess radiation exposure to commercial aircrews
- Fully physics-based model
  - Multiple components: SPE and GCR environment, nuclear and atomic interactions, **geomagnetic field, radiation transport** and atmosphere composition models
- Real time assessment with hourly updates
- Delivers a global map of radiation environment
- Assess the safety of a flight path in real-time




## R3S support NAIRAS

- Transfer NAIRAS from research to operations
- Reduce uncertainty in radiation transport model
- Map radiation exposure as a function of geomagnetic field strength.

# R3S Instruments

## Sensors

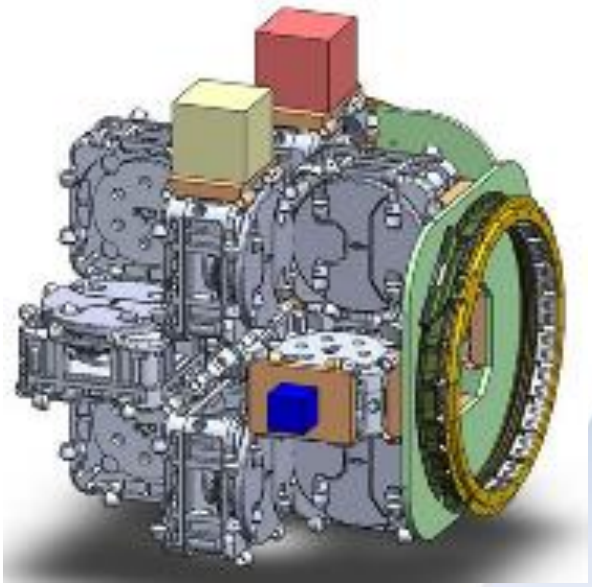
- Radiation environment
  - Liulin-6SA2 LET (Linear Energy Transfer) spectrometer
  - Teledyne µDosimeter TID (Total Ionizing Dose) detector
- Geomagnetic field
  - Honeywell HMR2300 magnetometer


**R3S sensors**

# Satlet Architectures

## Redefining satellite “morphology”

- Satlets are defined as cellularized satellites
- Satlets enable changing satellite design geometries to accommodate any potential payload



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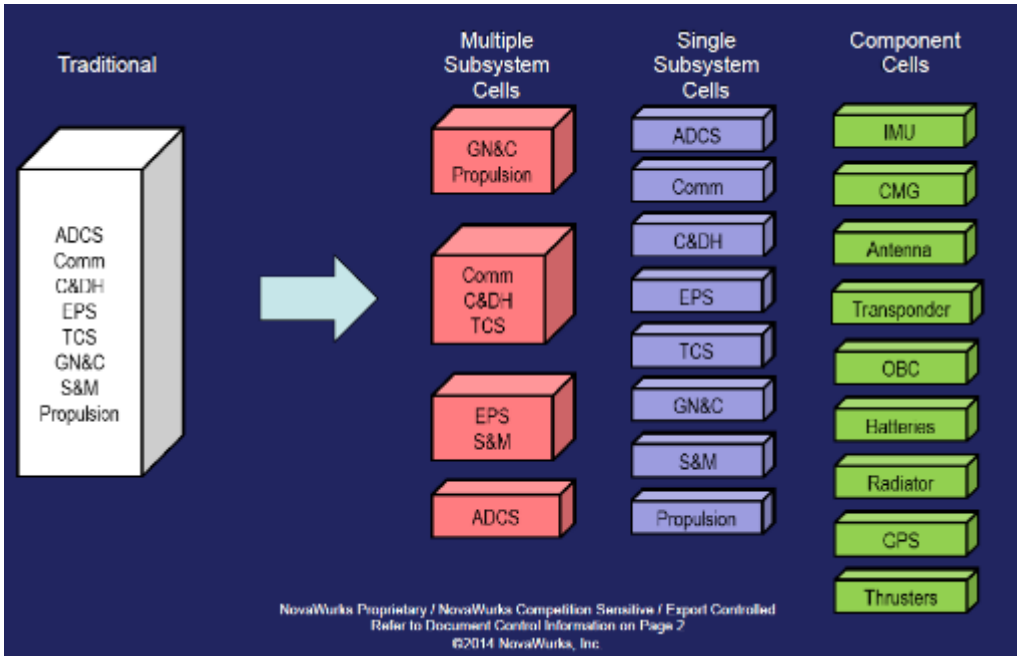
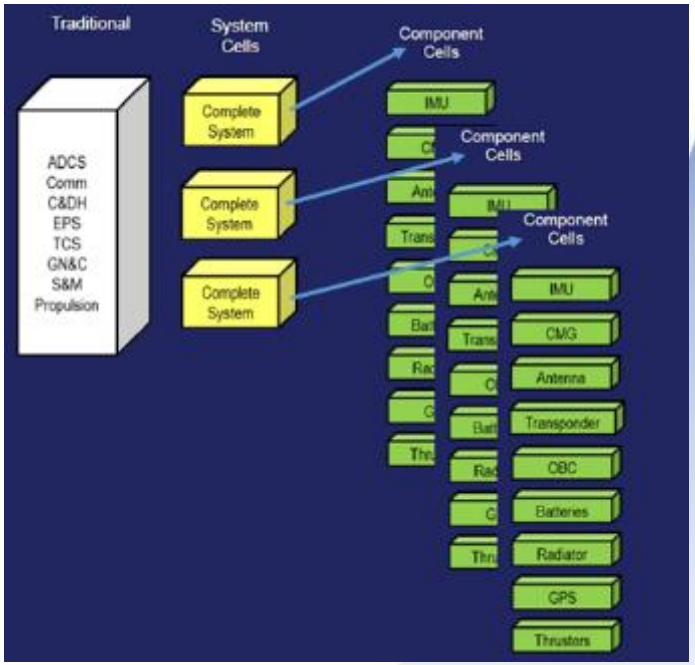
# Hyper Integrated Satlet (HISat)

## Cellularization

- Path to increased complexity without increased cost
- Standardized interface for component cells
- Software defined functionality of identical blocks




Traditional Bus Architecture

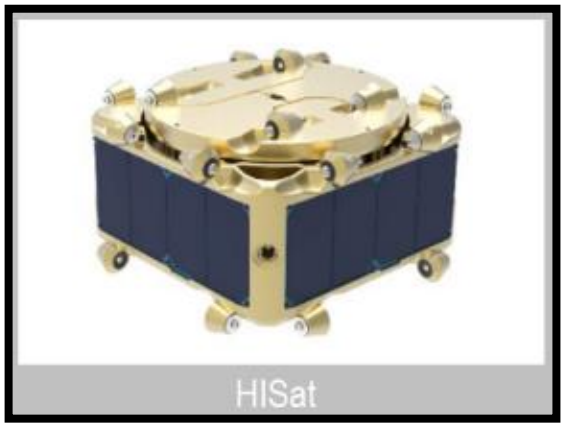



Cellularized Bus Architecture

# HISat Architecture

## Building Blocks

- Payload Adapter
- HiSat cells


## Package of Aggregated Cells (PAC)

- Payloads interface on User Defined Adapter (UDA)

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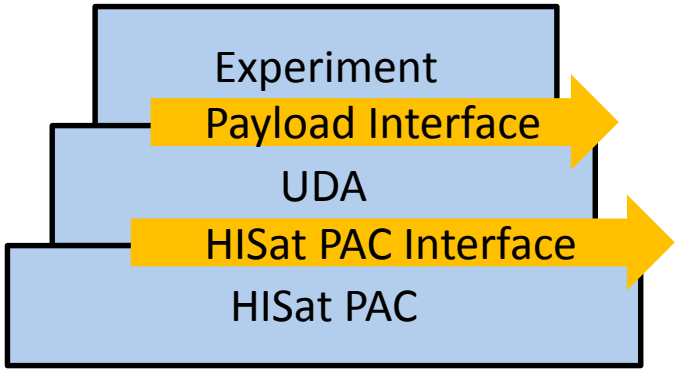
# HISat UDA (User Defined Adapter)

## Payload Interface

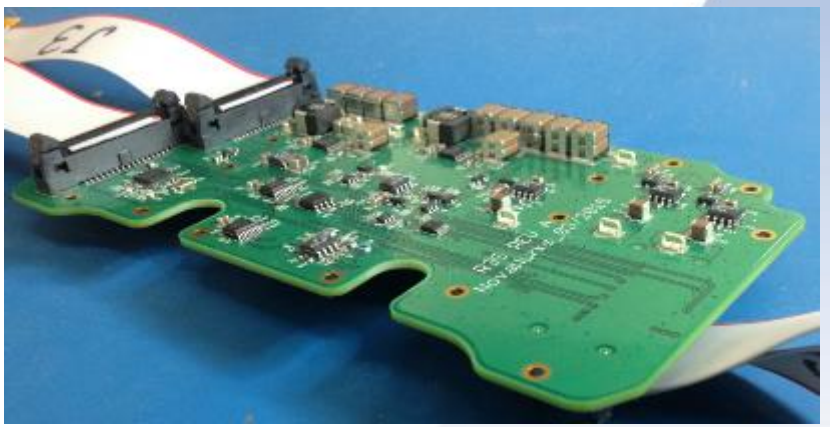
- Attach hosted payload to PAC (Package of Aggregated Cells)
- Standardized interface for experiment payload




**HISat interface architecture**

## Documents

- ICD: Novawurks Provides Design Document
- Safety document: LaRC provides safety document

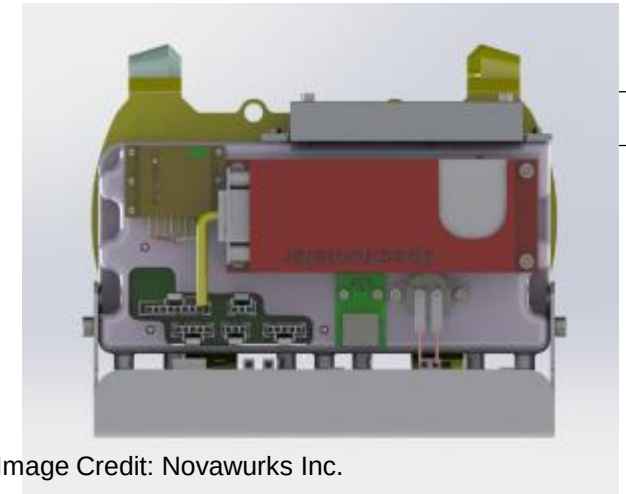


**R3S payload interface board**

# R3S UDA Interface

## Sensor configuration

- Minimally shielded



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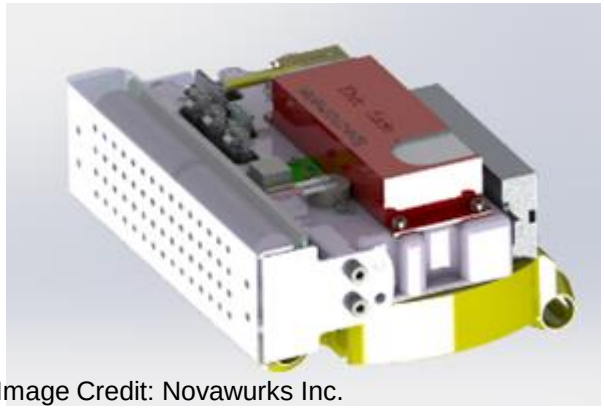

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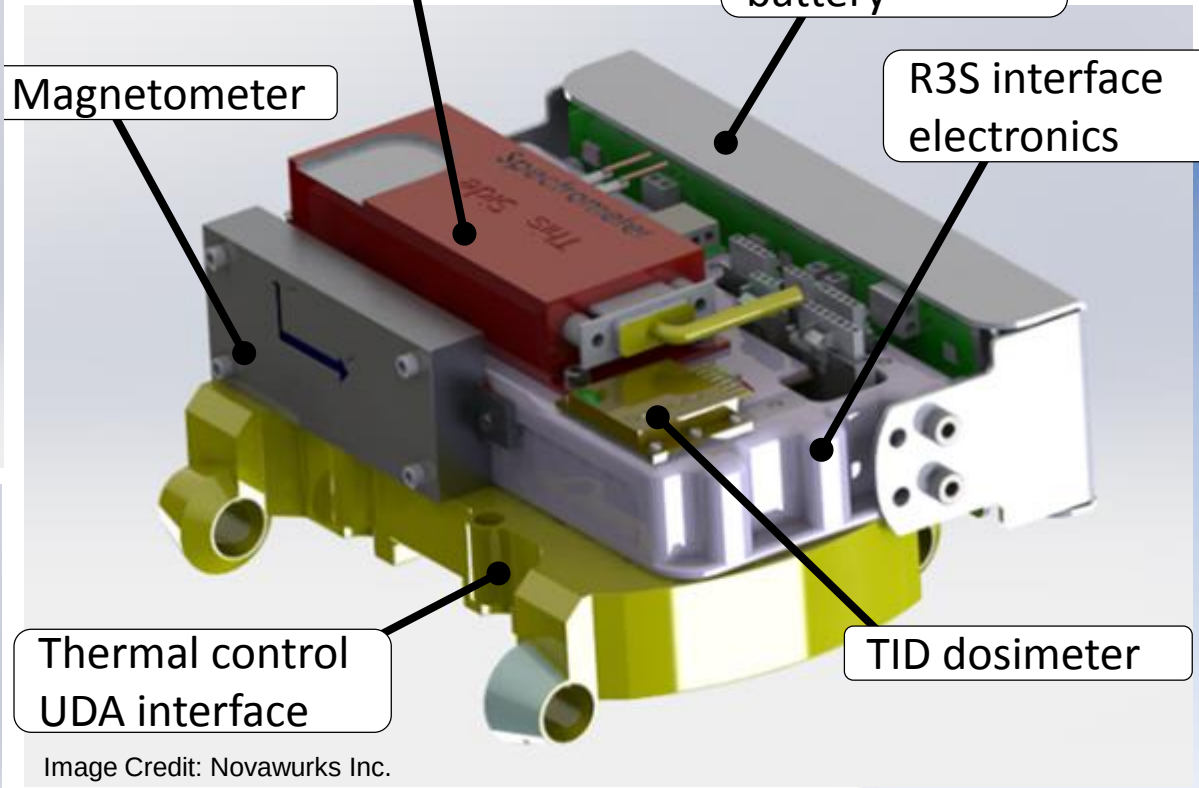


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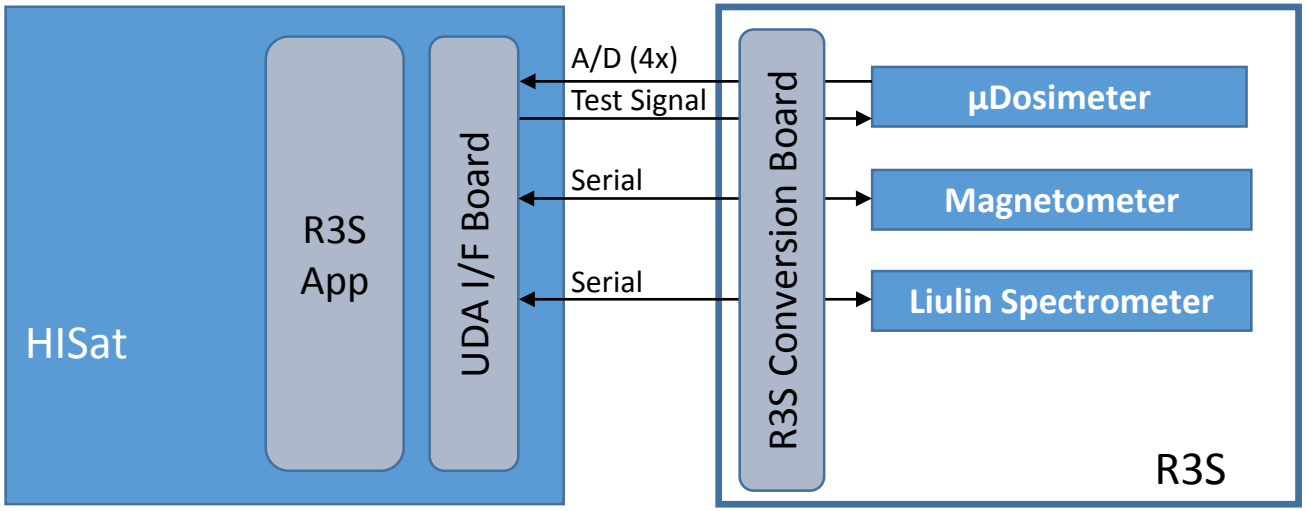
# R3S Operational Interface




R3S sensors

Science Data (.csv file)
Housekeeping data
Health data

Data:
R3S Content defined by LaRC
Format defined by NW

Satellite Ground Station

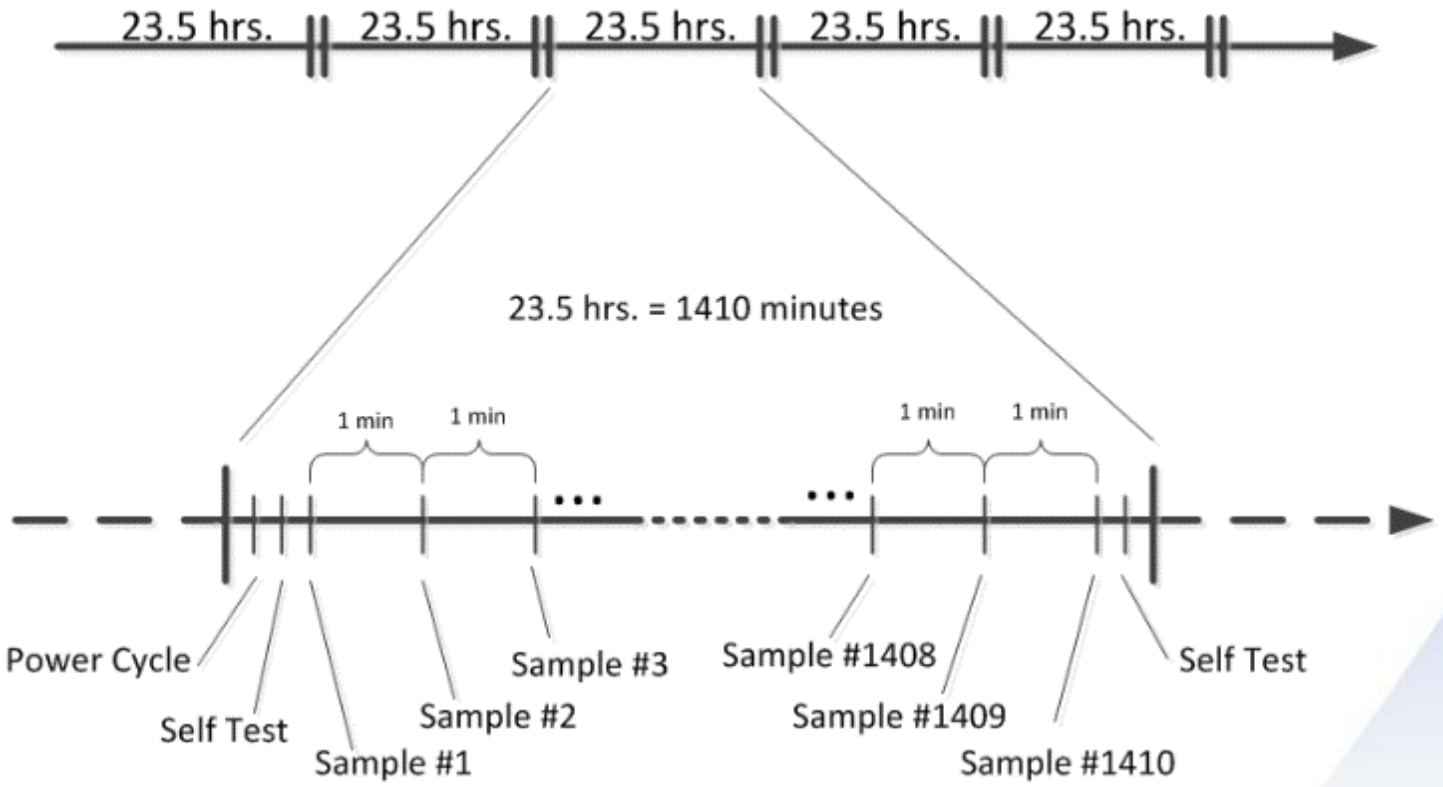
LaRC Ops

Operational commands

# R3S Con-Ops

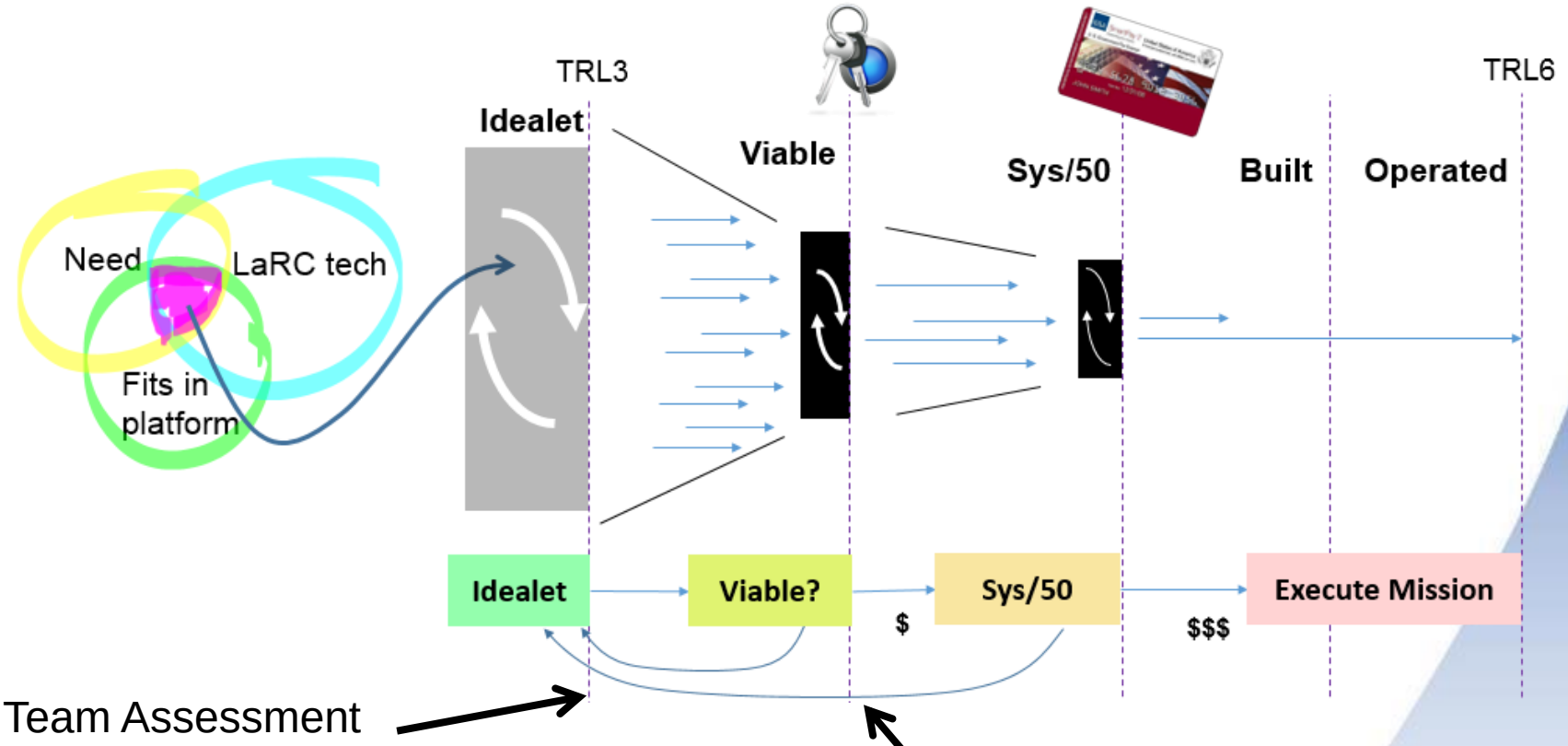
## R3S time-line

- Standard Data Take period of 23.5 hours
- Minimum mission is one Data Take



# Lab Vocabulary

## Lab77 Model: Mission Natural Selection




Team Assessment

- Desirable (aligns to a road map need)
- Has a team (able/willing to advance the concept)
- Fits in an available platform.

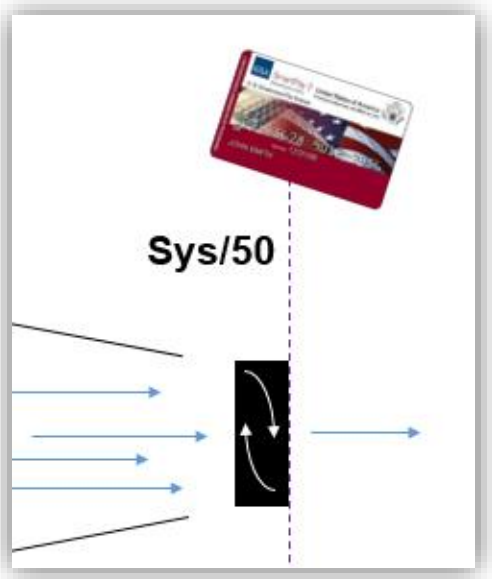
Management Assessment

- Aligns to a road map
- Technically feasible
- Team.

# Sys/50 Analysis

## Rapid concept developments

- Engineering of the system
- 50% design complete
- No “Gotchas”

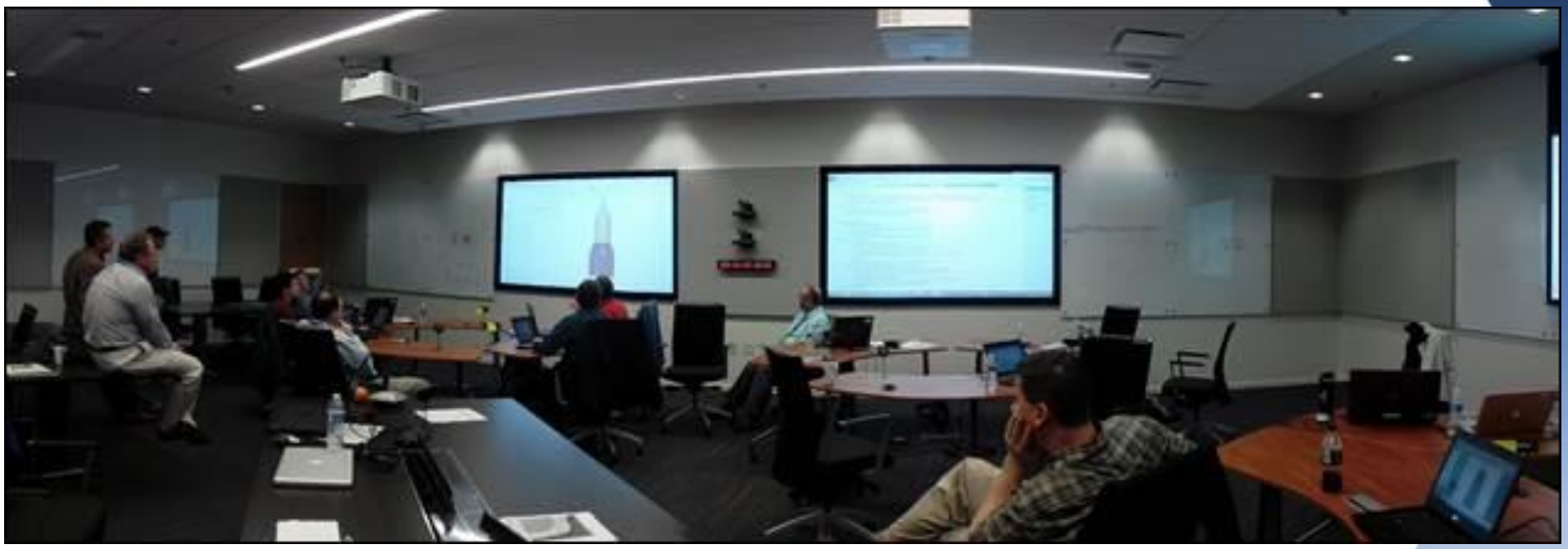



**Technical Feasibility Test**

**Elements of a Sys/50 Analysis**

| Systems Engineering | Design Engineering | Programmatic |
|---|---|---|
| - Con-ops<br>- Architecture<br>- Interface definition<br>- Con-ops system diagram | - Requirements<br>- Mechanical model<br>- Electrical block diagram with parts list<br>- Power budget<br>- Comm. design<br>- Cabling estimate<br>- Thermal analysis<br>- Structural analysis<br>- Software architecture<br>- Sensor system<br>- Testing and evaluation plan | - Cost & Schedule<br>- Review comments from senior engineers |

# Engineering Design Studio (EDS)



## Concurrent Engineering

- Entire system developed in parallel
- Facilitated conversations
- Collocated* for duration of the study
- 1st order engineering products developed in near real time

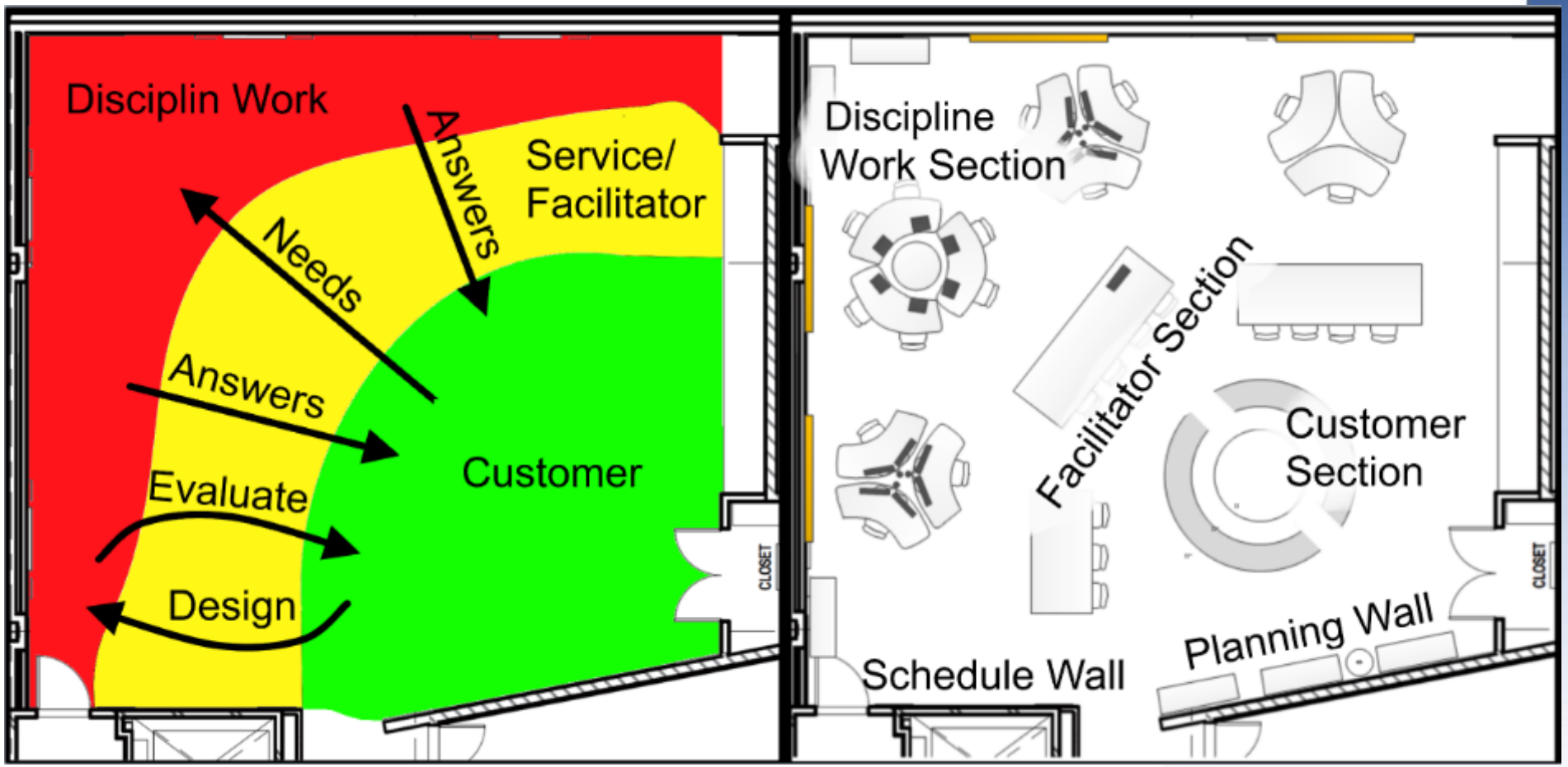
* tele-presence for remote team members

# LaRC EDS facility

"We shape our buildings; thereafter they shape us." - Winston Churchill

## EDS: Designed to design

- layout supports facilitated, concurrent, customer-in-the-loop activity

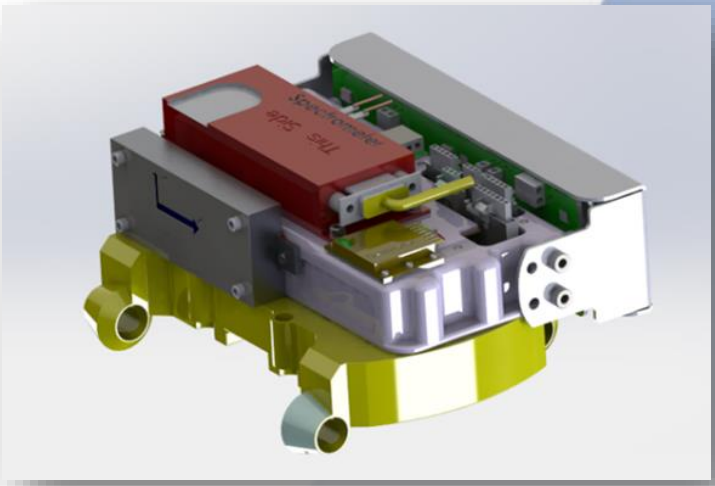


# Summary

## Rapid Response Radiation Survey (R3S)

- Made possible by:
  - Space Technology Mission Directorate
  - NovaWurks HISat architecture
- Supports Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) transition to operations
  - Reduce uncertainty in radiation transport model
  - Map radiation exposure as a function of geomagnetic field strength
- Developed using:
  - NovaWurks User Defined Adapter
  - Lab77 mission natural selection process
  - LaRC Engineering Design Studio (facilitated concurrent engineering)

Made possible in partnership with NovaWurks Inc.



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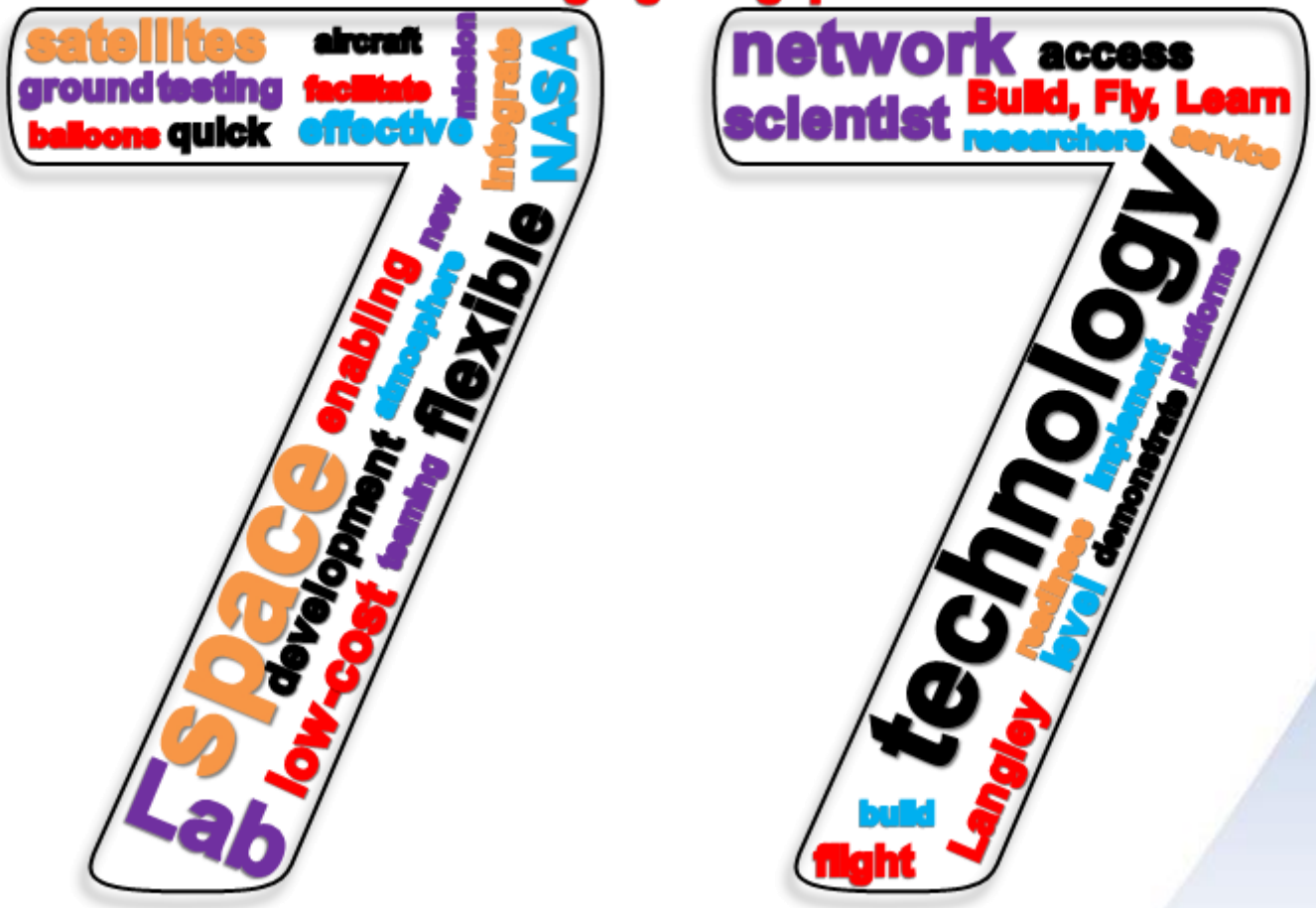
# Lab Seventy-Seven

bridging the gap



# BACKUP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# NAIRAS References


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# Characterization

- **Cesium 137**
  - Exposed to @ 3 dose rates/distances